SPH4U Unit 2 Practice Problems

1. Scooby has a mass of 46.5 kg. While running away from a ghost, Scooby ends up sliding across a frictionless surface. While sliding, Scooby collides with a 25.0 kg block that is sitting at rest on the ground, attached to one end of a 4.75 m long spring. The other end of the spring is attached to a wall, and the spring constant is equal to 980 N/m. Scooby hangs onto the block after the collision, and as a result Scooby and the block slide back and forth. After the collision, the spring compresses to a minimum total length of 2.00 m.
   a) How fast was Scooby sliding before colliding with the block?
   b) What was Scooby's maximum acceleration while holding onto the block?
   c) With what frequency will Scooby and the block slide back and forth after the collision?

2. Fred (87.5 kg) slid along a frictionless surface until he collided with Barney (79.2 kg) who was initially sitting at rest. Fred held on to Barney when he collided with him, and the two of them then slid into a horizontal spring. The spring constant for the spring is 1300 N/m, and the spring compressed a maximum of 2.75 m before Fred and Barney stopped sliding.
   a) What maximum acceleration do Fred and Barney have as they slow to rest?
   b) How fast was Fred sliding before colliding with Barney?
   c) For how much time after coming into contact with the spring do Fred and Barney continue to slide before stopping?

3. Tina Totallyoutofcontrol (47.3 kg) is careening along a frictionless surface when she smashes into Emily Enjoyingaquietday (63.8 kg) who is sitting at rest. As a result of the collision, the two become entangled and slide into a horizontal spring that is fixed to a wall at one end. The spring constant for the spring is 1250 N/m, and it compresses a maximum of 3.50 m while bringing Tina and Emily to rest.
   a) What is the maximum acceleration experienced by Tina and Emily due to the spring?
   b) How fast was Tina sliding before crashing into Emily?
   c) If Tina and Emily stick to the end of the spring, how long will it take for them to make one complete oscillation?

4. Shaggy is driving his bumper car (158.3 kg total mass) at 4.75 m/s [N] when he has a completely elastic collision with Velma who is driving her bumper car (141.2 kg total mass) at 2.25 m/s [S].
   a) How fast (velocity) is each of the bumper cars moving when the system has its maximum amount of potential energy?
   b) What is the velocity of each car immediately after the collision?
   c) How much thermal energy is produced during this collision?

5. Pebbles and Bambam played a game of marbles in which Pebbles rolled her 125 g marble with an initial velocity of 75.0 cm/s [E] and Bambam rolled his 110 g marble with an initial velocity of 58.0 cm/s [S50W]. The marbles collided, and as a result Pebbles' marble had a velocity of 46.0 cm/s [S70˚E].
   a) What was the velocity of Bambam's marble immediately after the collision?
   b) What type of collision did the marbles have? Justify your answer.

6. Ian Idontgethurt (143 kg) moving at 25.0 km/h [N] collides elastically with Ross Runningistoomuchwork (78.0 kg) moving at 5.00 km/h [N].
   a) What velocity does each person have immediately after the collision?
   b) What maximum amount of energy is removed from KE during the collision?

7. Fred is driving his hovercar (264 kg total mass) at 3.80 m/s [E] when he collides with Daphne who is driving her hovercar (219 kg total mass) at 5.30 m/s [N30°E]. Immediately after the collision, Fred is sliding along at 4.20 m/s [N65E].
   a) What is Daphne's velocity immediately after the collision?
   b) What type of collision did they have? Justify your answer.

8. Betty and Wilma spent the afternoon at the Bedrock Bumpercars. Betty (total mass of 127.0 kg) was traveling at 4.80 m/s [S] when she collided elastically with Wilma (total mass of 139.0 kg) who was traveling at 3.60 m/s [N].
   a) What is the velocity of each car when they are as close together as they will get?
   b) What is the velocity of each car immediately after they stop touching each other?
   c) Why do the bumpers not change temperature because of the collision?

9. Alex AllIwannadoisdrive is driving his bumper car (total mass 198 kg) at 5.40 m/s [W] when he collides with Kevin Keepouttamyway who is driving his bumper car (total mass 253 kg) at 3.60 m/s [E30˚N]. As a result of the collision (which lasts for 0.750 s) Kevin's velocity changes to 2.30 m/s [E].
   a) What is Alex's velocity after the collision?
   b) What average force does Kevin exert upon Alex during the collision?
   c) What type of collision is this? Justify your answer.

10. Scrappy Doo (total mass including space suite of 68.0 kg) has been sent into orbit in order to provide surveillance. Scrappy orbits the Earth with a constant orbital radius of 1.25×10^7 m.
   a) How long does it take for Scrappy to make one complete orbit of Earth? Answer in reasonable units.
   b) What is Scrappy's total energy while in orbit?
   c) Scrappy uses a pendulum clock in order to keep track of time. Will his pendulum have the same period while in orbit as it does on the surface of Earth? Explain your answer as best you can.
   d) What would happen to Scrappy's orbital path if he fired his rocket boosters (for a few seconds only), causing his speed to increase by 10%? Give as complete an answer as you are able.

11. Dino (the 125 kg dinosaur) decided to take a trip on a rocket ship to see what outer space is like. Dino orbited Earth in circular orbit with an orbital radius of 9.24×10^6 m.
   a) What is Dino's orbital period? Answer in reasonable units.
   b) What is the sum of PE_g and KE that Dino has while in orbit?
   c) How fast is Dino moving, and what is his acceleration?
   d) If a pendulum with a length of 1.25 m, a bob mass of 578 g and an angle of release of 20˚ were situated at the same altitude as Dino, what would its period of oscillation be?
   e) Fred wants to throw a 685-g can of Dinotreats up to Dino. How fast will it have to be moving when it leaves the surface of Earth in order to just make it to Dino's orbital position?

12. Leah Leavemealone hopped into her spacecraft (total mass 655 kg) and headed for orbit around Earth. Leah orbited in a circular path at a constant speed of 856 m/s.
   a) What is Leah's orbital radius and acceleration?
   b) What is Leah's orbital period? Answer in reasonable units.
   c) Calculate Leah's KE, PE_g and E_{total} while in orbit.
   d) Elaine Eatmoredonuts wants to send a package of deep-fried goodness up to Leah. What speed should she throw it up at in order for it to just make it as high as Leah's orbital position?
   e) Leah needs to change her speed in order intercept Elaine's package. Explain why a propeller does not work, but a rocket engine does while in the vacuum of outer space. Give as much detail as you are able.
   f) A pendulum is located at the same position above Earth's surface as Leah's orbit. The pendulum has a length of 1.75 m, a bob of 780 g and was released from an angle of 25˚. How long will it take for the pendulum to make one complete oscillation?

13. Elissa Ejectorbooks took all of her physics notes and threw them directly away from the surface of Earth with a velocity of 922 m/s [straight up]. Ignore air resistance.
   a) What maximum height above Earth's surface will Elissa's notes reach before they start to fall back down?
   b) Sketch a graph of energy versus **time** for the notes. On a single set of axis draw and label three lines: total energy, kinetic energy, and gravitational potential energy.

1. a) $v_I = 15.7$ m/s, b) $a = 37.7$ m/s^2, c) $f = 0.589$ Hz
2. a) $a = 21.4$ m/s^2, b) $v_I = 14.6$ m/s, c) $\Delta t = 0.562$ s
3. a) $a = 39.4$ m/s^2, b) $v_I = 27.6$ m/s, c) $T = 1.87$ s
4. a) $v' = 1.45$ m/s [N], b) $v_S' = 1.85$ m/s [S], $v_V' = 5.15$ m/s [N]
5. a) $v_B' = 21.1$ cm/s [S23°W], b) Partially elastic - lost 71% of initial KE
6. a) $v_I' = 10.9$ km/h [N], $v_R' = 30.9$ km/h [N], b) PE = 779 J
7. a) $v_D' = 3.60$ m/s [N47°E], b) Partially elastic - lost 25% of initial KE
8. a) $v' = 0.410$ m/s [S], b) $v_B' = 3.98$ m/s [N], $v_W' = 4.42$ m/s [S]
9. a) $v_A' = 4.93$ m/s [W28°N], b) F = 667 N [W66°N] c) Partially elastic - lost 32% of initial KE
10. a) T = 3.86 hours, b) $E_{tot} = -1.08$ GJ, c) no, different g, in feefall, d) path would become elliptical
11. a) T = 2.45 hours, b) $PE_g + KE = -2.698$ GJ, c) $v = 6.57$ km/s, $a = 4.67$ m/s^2, d) T = 3.25 s, e) $v = 6.22$ km/s
12. a) $r = 5.44 \times 10^8$ m, $a = 1.35$ mm/s^2, b) T = 46.25 days, c) $PE_g = -480$ MJ, KE = 240 MJ, $E_{tot} = -240$ MJ, d) $v = 11.12$ km/s, e) conservation of momentum, f) T = 227 s
13. a) $\Delta h = 43.7$ km